BULK MATERIAL PUMP FEEDER WITH REDUCED DISK JAMMING

RELATED APPLICATION

The present application is a continuation-in-part of pending U.S. Patent Application No. 10/119,359 filed on behalf of inventors Timothy R. Baer and James T. Foley on April 9, 2002, titled "Bulk Material Pump Feeder," assigned to the assignee of the present application, and incorporated in this application by reference.

TECHNICAL FIELD

The present invention relates, in general, to materials handling equipment and, in particular, to a pump feeder of materials handling equipment that feeds bulk materials.

BACKGROUND OF THE INVENTION

In certain bulk materials handling equipment, such as the equipment described and illustrated in U.S. Patent No. 5,051,041 and U.S. Patent No. 5,355,993, a pump feeder moves bulk material through a housing from an inlet to an outlet by a rotating drive rotor having two or more drive disks mounted to or integral with a rotating hub. In the past, this type of equipment has been used for feeding coal and other breakable material having uniform and non-uniform gradation. Typically, the drive systems for this equipment have delivered large torque at slow speed.

As such equipment is adapted to handle different materials supplied in different sizes, problems that have not been encountered previously are arising. One such problem of major importance is the tendency of smaller size equipment, handling harder, smaller size material such as plastic, to stall, sometimes only temporarily, as the material being handled wedges between the rotating drive rotor and the housing or stationary parts mounted to the housing. This wedging of material can occur, for example, between the drive disks of the drive rotor and the housing inner wall or between the hub of the drive rotor and a materials scraper mounted to the inner wall of the housing.

Simply increasing the drive power (i.e., providing a larger drive motor) to overcome the wedging is not, in most instances, an adequate or satisfactory solution to the problem. Cost and space limitations are but two restrictions on simply providing increased drive power. Certain of the materials being handled are not easily breakable, so a larger drive motor merely increases the effect of the material wedging between the rotating drive rotor and the housing or stationary parts mounted to the housing. Thus, a larger drive motor can exacerbate the problem, resulting in a complete stoppage of operation and damage to the equipment. With breakable materials, such as coal, the drive torque is large enough to break or pulverize the material into smaller pieces that do not wedge between the rotating drive rotor and the housing or stationary parts mounted to the housing.

Although this adverse wedging effect might not be a regular occurrence and is likely to be different for handling different types of material, when it does occur, even temporarily, it affects accuracy and feeder performance to an unacceptable extent. Because the tendency of the equipment to stall, either temporarily or for longer periods of time, due to this wedging is greater at higher speed operation of the equipment, slowing down the operation of the equipment to reduce the likelihood of material wedging, while possibly reducing the likelihood of wedging, also is unacceptable.

To overcome the shortcomings of existing devices, a new bulk materials pump feeder is provided. An object of the present invention is to provide an improved bulk materials pump feeder that minimizes jamming of the disks. A related object is to prevent stall, even temporarily, caused as the material being handled wedges between the rotating drive rotor and the housing or stationary parts mounted to the housing. Another object is to avoid having to increase the drive power to overcome the wedging problem. It is still another object of the present invention to achieve these advantages within the confines of cost and space limitations. Yet another object of this invention is to provide a bulk materials pump feeder adapted to handle a wide variety of different materials supplied in different sizes. Additional objects are to achieve accuracy and assure optimal feeder performance.

SUMMARY OF THE INVENTION

To achieve these and other objects, and in view of its purposes, the present invention provides a bulk materials pump feeder. The bulk materials pump feeder, as constructed in accordance with the present invention, includes a housing having an inlet, an outlet, and an inner wall extending from the inlet of the housing to the outlet of the housing. This bulk materials pump feeder also includes a drive rotor having a hub rotatable about a rotation axis and a plurality of drive disks (two are illustrated, but more are possible) extending away from the hub toward the inner wall of the housing.

Three structural embodiments or features of the bulk materials pump feeder reduce the tendency of material to jam between the drive rotor and the housing or other stationary parts mounted to the housing. First, the distance between the circumferential edges of the drive disks and the housing inner wall increases from the inlet to the outlet in the direction of rotation of the drive rotor. Second, a low-friction brush seal disposed on the periphery of the drive disks seals

the area between the periphery of the drive disks and the inner wall. Finally, a materials scraper having a flexible tip is mounted in the housing and extends into the drive rotor between the drive disks. The inner wall of the housing, the drive disks, and the hub define a materials transfer duct through which material is transferred from the inlet of the housing to the outlet of the housing.

The three embodiments of the present invention may be independently incorporated in the bulk materials pump feeder according to the present invention. Alternatively, any two or even all three of the embodiments can be combined into a single bulk materials pump feeder. At least for certain applications, such combination may be expected to achieve a synergistic effect.

It is to be understood that both the foregoing general description and the following detailed description are exemplary, but are not restrictive, of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The invention is best understood from the following detailed description when read in connection with the accompanying drawing. It is emphasized that, according to common practice, the various features of the drawing are not to scale. On the contrary, the dimensions of the various features are arbitrarily expanded or reduced for clarity. Included in the drawing are the following figures:

Fig. 1 is an exploded, perspective view of a bulk materials pump feeder constructed in accordance with a first embodiment of the present invention;

Fig. 2 is a side view of the bulk materials pump feeder shown in Fig. 1;

Fig. 3 is a schematic drawing of the relationship between the drive disks and the inner wall of the housing of the bulk materials pump feeder shown in Figs. 1 and 2;

Fig. 4 is a side view showing the relationship of the drive rotor hub and the materials scraper illustrated in Fig. 1;

Fig. 5 is a side view showing the relationship of the drive rotor hub illustrated in Fig. 1 and a second materials scraper;

Fig. 6 is an exploded, perspective view of a bulk materials pump feeder constructed in accordance with a second embodiment of the present invention;

Fig. 7 is an exploded, perspective view of the drive disks of the bulk materials pump feeder shown in Fig. 6;

Fig. 8 is a perspective view of a third materials scraper of the bulk materials pump feeder constructed in accordance with a third embodiment of the present invention; and

Fig. 9 is an exploded, perspective view of a bulk materials pump feeder constructed in accordance with the third embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figs. 1 and 2, a bulk materials pump feeder, constructed in accordance with the present invention, includes a housing **10** having an inlet **12**, an outlet **14**, and an inner wall **16** extending from inlet **12** to outlet **14**. A bulk materials pump feeder, constructed in accordance with the present invention, is generally similar in construction and operation to the units described and illustrated in U.S. Patent No. 5,051,041 and U.S. Patent No. 5,355,993, the contents of which are incorporated in this document by reference.

The bulk materials pump feeder of Figs. 1 and 2 also has a drive rotor **18** having a hub **20**, which is rotatable about a rotation axis **22**, and a pair of drive disks **24** which extend away from hub **20** toward inner wall **16** of housing **10**. For the embodiment of the invention being described, hub **20** and drive disks **24** are formed as a single, integral, monolithic unit. Drive disks **24** can be formed with radially extending discontinuities on the interior faces as described and illustrated in U.S. Patent No. 5,355,993 to facilitate transfer of material from inlet **12** to outlet **14** of housing **10**. Preferably, the outside surfaces of drive disks **24** each have a bevel **24a** at the circumferential edge of the drive disk for a reason to be explained below.

Drive rotor **18** is mounted in housing **10** for rotation about rotation axis **22** and is held in place by, for example, a screw **25**. For the embodiment of the invention illustrated in the figures and being described, drive rotor **18** has two drive disks **24**. Drive rotor **18** can be arranged, however, to have more than two drive disks **24**. The number of drive disks **24** to be included in drive rotor **18** is dependent on the particular application of the bulk materials pump feeder (i.e., materials being transferred, performance specifications, etc.).

A. First Embodiment

As shown most clearly in Fig. 3, which is a schematic drawing of the relationship between drive disks **24** and inner wall **16** of housing **10**, the distance between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** increases from INLET **12** of housing **10** to OUTLET **14** of housing **10** in the direction of rotation of drive rotor **18**, which is clockwise as indicated by the arrow for the embodiment of the invention illustrated in the figures and being described. Drive disks **24** and inner wall **16** of housing **10** can be shaped in different ways to provide the desired spacing between the two components. For the embodiment of the invention illustrated in the figures and being described, drive disks **24** are circular and extend away from hub **20** perpendicular to rotation axis **22** of hub **20**, and inner wall **16** of housing **10** is spiral shaped. The spiral-shaped inner wall **16** of housing **10** can be defined by the Archimedes spiral equation:

$$R = \theta * a$$

where: "R" is the radius; "θ" is the polar angle; and "a" is the rate of radial increase given in some unit of measure per angular unit, such as mm/degree. The distance between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** is exaggerated in Fig. 3 for purposes of illustration.

For the embodiment of the present invention represented by Fig. 3, the desired increasing distance between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** is effected by the spiral shape of inner wall **16** of housing **10**. This desired increasing distance between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** might also be achieved by the design and provision of alternative components or by a combination of the design of such alternative components and the design of inner wall **16** of housing **10**.

Inner wall **16** of housing **10**, the inside surfaces of drive disks **24**, and hub **20** define a materials transfer duct through which material is transferred from inlet **12** of housing **10** to outlet **14** of housing **10**. Drive rotor **18** is rotated by a motor (not shown) coupled to drive rotor **18** by a suitable mechanism. As drive rotor **18** is rotated, drive disks **24** cause material, introduced into the bulk materials pump feeder through inlet **12** of housing **10**, to be transferred to outlet **14** of housing **10** where the material is discharged from the bulk materials pump feeder.

Pieces of material being transferred through the bulk materials pump feeder from inlet **12** to outlet **14** that tend to wedge between inner wall **16** of housing **10** and the circumferential edges of drive disks **24** move in the direction of rotation of drive rotor **18** to a larger spacing between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** and do not wedge because of the increasing space between the circumferential edges of drive disks **24** and inner wall

16 of housing **10**. Instead, this material is discharged through outlet **14**. By beveling the outside surfaces of drive disks **24** at the circumferential edges, the surface areas of the circumferential edges of drive disks **24** are minimized, thereby reducing the tendency of material to wedge between drive disks **24** and inner wall **16** of housing **10**.

Referring to Figs. 1, 2, and 4, a bulk materials pump feeder, constructed in accordance with the present invention, preferably includes a materials scraper **26** that is mounted in a recess **28** in inner wall **16** of housing **10** downstream from outlet **14** and upstream from inlet **12**. Materials scraper **26** extends into drive rotor **18** in the space between the interior faces of drive disks **24** almost touching hub **20**.

Certain materials that are transferred through the bulk materials pump feeder will cling, under certain conditions, to drive rotor **18**. Such clinging material may not be discharged through outlet **14**. Materials scraper **26** scrapes clinging material from drive rotor **18** and, generally, this material falls back and is discharged successfully through outlet **14**.

Materials scraper **26** has two surfaces **30** (only one is illustrated in Fig. 1) that face the circumferential edges of drive disks **24**. The distance between surfaces **30** of materials scraper **26** and the circumferential edges of drive disks **24** increases in the direction of rotation of drive rotor **18** from the distance between inner wall **16** of housing **10** and the circumferential edges of drive disks **24** at outlet **14** of housing **10** to the distance between inner wall **16** of housing **10** and the circumferential edges of drive disks **24** at inlet **12** of housing **10**. In particular, surfaces **30** of materials scraper **26** are continuations, in effect, of inner wall **16** of housing **10**, so that material that is not discharged at outlet **14** that tends to wedge between materials scraper **26** and the circumferential edges of drive disks **24** moves

in the direction of rotation of drive rotor **18** to a larger spacing between drive disks **24** and materials scraper **26** and either falls back and is discharged through outlet **14** or falls into material that is introduced at inlet **12**. The increasing space between surfaces **30** of materials scraper **26** and the circumferential edges of drive disks **24**, from OUTLET **14** to INLET **12**, is illustrated in Fig. 3.

Materials scraper **26** that is illustrated in Figs. 1 and 4 has a plurality of scraping tips **26a**, **26b**, and **26c** that scrape material that is not discharged at outlet **14**. As illustrated in Fig. 4, the spacing between materials scraper **26** and hub **20**, specifically the spacing between scraping tips **26a**, **26b**, and **26c** and hub **20**, increases in the direction of rotation of drive rotor **18** from outlet **14** to inlet **12** to reduce, or even eliminate, the tendency of material to wedge between materials scraper **26** and hub **20**. Scraping tips **26a**, **26b**, and **26c** can be points on a spiral or simply points that are spaced from hub **20** the desired distances.

A second form of materials scraper **36** is illustrated in Fig. 5. Materials scraper **36** of Fig. 5 has a continuous scraping surface **40**, rather than a plurality of scraping tips **26a**, **26b**, and **26c** as in materials scraper **26** shown in Fig. 4. The spacing between scraping surface **40** of materials scraper **36** and hub **20** increases in the direction of rotation of drive rotor **18** from outlet **14** to inlet **12** to reduce, or even eliminate, the tendency of material to wedge between materials scraper **36** and hub **20**. Scraping surface **40** of materials scraper **36** can be spiral shaped.

In the first embodiment of the present invention described above, the distance between the circumferential edges of drive disks **24** and inner wall **16** of housing **10** increases from INLET **12** of housing **10** to OUTLET **14** of housing **10** in the direction of rotation of drive rotor **18**. The material being transferred through the bulk materials pump feeder does not wedge because of the increasing space between the circumferential edges of drive disks **24** and inner wall **16** of housing **10**. Two other embodiments of the present invention also reduce the possibility of material jamming drive disks **24** when the bulk materials pump feeder is in operation.

B. Second Embodiment

In the second embodiment of the present invention, as illustrated in Figs. 6 and 7, a low-friction brush seal **50** is disposed on the periphery of drive disks **24**. Brush seal **50** may be made of a number of different materials including, for example, pipe cleaner and rope. Brush seal **50** also may be constructed by combining a base made of metal, such as carbon steel, stainless steel, or aluminum, with a non-metallic brush made of a natural or synthetic fiber.

It is not necessary that brush seal **50** form a perfect seal between the periphery of drive disks **24** and inner wall **16** of housing **10**. Although a small amount of contact occurs between brush seal **50** and inner wall **16** of housing **10**, brush seal **50** induces little or no friction between drive disks **24** and inner wall **16** of housing **10** as drive disks **24** rotate. A low-friction seal is important to avoid an extra load on the drive motor. Moreover, the addition of brush seal **50** does not introduce tolerance issues into the design of the bulk materials pump feeder.

Brush seal **50** may be attached to the periphery of drive disks **24** in a variety of ways. For example, brush seal **50** may be adhered to drive disks **24** using an adhesive such as glue. A presently preferred method for attaching brush seal **50** to drive disks **24** is to provide a groove or channel **52** in the edges of drive disks **24** that form the periphery of drive disks **24**. Brush seal **50** is packed (i.e., wedged) into channel **52** in the edge of each drive disk **24**. Of course, various methods may be combined to attach brush seal **50** to drive disks **24**. Thus, for example, brush seal **50** may be both packed into and glued to channel **52**.

Brush seal **50** prevents or at least minimizes the possibility of particles, which are sufficiently large to cause problems, from entering the region between the peripheral edges of drive disks **24** and housing **10**. Particles that are sufficiently small to pass through brush seal **50** are unlikely to cause problems.

Brush seal **50** achieves its function well for both pellet and powder materials. A specific benefit achieved by brush seal **50** for applications involving powder materials is that the material does not build up or grind between the peripheral edges of drive disks **24** and inner wall **16** of housing **10**.

Brush seal **50** prevents or at least minimizes the possibility of particles wedging between the peripheral edges of drive disks **24** and inner wall **16** of housing **10**. Brush seal **50** also prevents or at least minimizes the possibility of particles passing through the gap formed between drive disks **24** and inner wall **16** of housing **10**. Thus, brush seal **50** helps to retain particles in the materials transfer duct defined by inner wall **16** of housing **10**, the inside surfaces of drive disks **24**, and hub **20**, preventing the particles from causing problems by interfering with components of the bulk materials pump feeder outside the materials transfer duct. Such retention also achieves the advantage of a cleaner bulk materials pump feeder, minimizing the need to clean and promoting the aesthetic appeal of the bulk materials pump feeder.

As mentioned above, drive disks **24** can be formed with radially extending discontinuities on the interior faces as described and illustrated in U.S. Patent No. 5,355,993 to facilitate transfer of material from inlet **12** to outlet **14** of housing **10**. As illustrated in Figs. 6 and 7, the interior faces of drive disks **24** can have other features that give such faces texture. Dimples **54** are shown in Figs. 6 and 7.

Textural features such as dimples **54** increase the friction between drive disks **24** and the material being handled by the bulk materials pump feeder. Such friction facilitates movement of the material through the materials transfer duct. Because optimal performance of the materials transfer duct depends upon a consistent, linear relationship between the material feed rate and the speed of the bulk materials pump feeder, slippage must be avoided. Some friction between drive disks **24** and the material being handled by the bulk materials pump feeder avoids slippage and helps to assure a linear speed of materials delivery.

As would be understood by a person of ordinary skill in the art, the two embodiments of the present invention described above may be independently incorporated in the bulk materials pump feeder according to the present invention. Alternatively, the two embodiments can be combined into a single bulk materials pump feeder. At least for certain applications, such combination may be expected to achieve a synergistic effect.

C. *Third Embodiment*

In the third embodiment of the present invention, as illustrated in Figs. 8 and 9, a third form of materials scraper **56** is provided. As illustrated in Fig. 8, materials scraper **56** may have a continuous scraping surface **40** like materials scraper **36** of Fig. 5. Alternatively, as illustrated in Fig. 9, materials scraper **56** may have a plurality of scraping tips **26a**, **26b**, and **26c** as does materials scraper **26** shown in Fig. 4.

The function of materials scraper **56** is to scrape the materials handled by the bulk materials pump feeder from drive disks **24** and hub **20** as the materials exit the bulk materials pump feeder. For many materials, such scraping is unnecessary. Materials scraper **56** is especially adapted for those applications which require no or only a minimal amount of scraping. Specifically, relative to materials scraper **26** of Fig. 4 and materials scraper **36** of Fig. 5, a majority of the structure forming materials scraper **56** has been eliminated (shown best in Fig. 8). In addition, materials scraper **56** has been provided with a flexible tip **58**. Flexible tip **58** may be made of any suitable material; an elastomer or a clear plastic are acceptable. Preferably, flexible tip **58** is conductive so that electrostatic charge is dissipated. Electrostatic charge can build up or be derived from the passage of charged particles through a medium or conduit composed of essentially non-conductive materials.

Flexible tip **58** allows material to enter the bulk materials pump feeder through inlet **12** in its normal fashion, but prevents the material from flowing backward to the discharge point proximate outlet **14**. Were flexible tip **58** omitted

entirely from materials scraper **56**, material could leak backward through the bulk materials pump feeder. In addition, when the bulk materials pump feeder is operating to feed material, some material tends to be carried by drive disks **24** and hub **20** past the discharge point--mainly due to the static charge of the material. The material clinging to the drive disks **24** and hub **20** tends to become caught or wedged between drive disks **24** and the materials scraper, jamming the bulk materials pump feeder. Flexible tip **58** solves this problem: materials that travel around past the discharge point either are deflected by flexible tip **58** and enter outlet **14** or pass by flexible tip **58** and reenter the materials stream directed toward the discharge. Materials scraper **56** having flexible tip **58** also prevents materials from jamming between the sides of drive disks **24** and the materials scraper.

Materials scraper **56** provides yet another advantage. Discussed above are the benefits provided by texturing the interior faces of drive disks **24** with such features as dimples **54** shown in Figs. 6 and 7. It would be similarly advantageous to give hub **20** texture **60**, shown in Fig. 7, in addition to texturing the interior faces of drive disks **24**. Texture **60** on hub **20** has a drawback, however, because most materials tend to wedge between the textured areas (e.g., dimples) of hub **20** and materials scraper **26, 36**. Thus, for most materials handled by the bulk materials pump feeder, it is not possible to texture hub **20** and the benefits of such texturing are lost. Because materials scraper **56** having flexible tip **58** minimizes the tendency of materials to wedge between texture **60** of hub **20** and materials scraper **56**, however, incorporation of materials scraper **56** into the bulk materials pump feeder permits hub **20** to have texture **60**. Thus, the advantages of texturing hub **20** are achieved.

As would be understood by a person of ordinary skill in the art, the three embodiments of the present invention described above may be independently incorporated in the bulk materials pump feeder according to the present invention. Alternatively, any two or even all three of the embodiments can be combined into a single bulk materials pump feeder. At least for certain applications, such combination may be expected to achieve a synergistic effect.

Although illustrated and described above with reference to certain specific embodiments, the present invention nevertheless is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the spirit of the invention.